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THE PREDICTION OF PERFORMANCE IN NAVY SIGNALMAN CLASS 'A' SCHOOL

SEPTEMBER 1980

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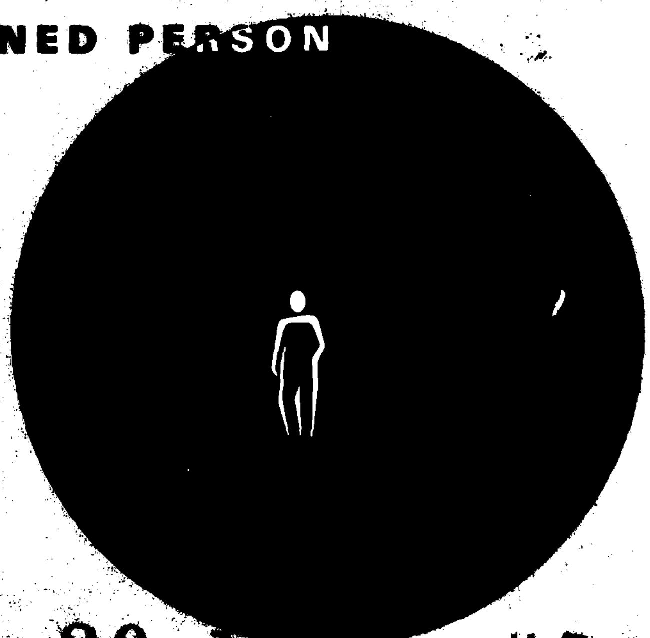

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TRAINING ANALYSIS AND EVALUATION GROUP
ORLANDO FLORIDA 32813

14 TAEG ~~Report No.~~ -90

6 THE PREDICTION OF PERFORMANCE IN NAVY SIGNALMAN CLASS 'A' SCHOOL.

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The work on this study was done during the period February to June 1979. Portions of this report were used in partial fulfillment of the requirements for the award of the Ph.D. degree to the author.

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Navy enlisted personnel enrolled in the Signalman course were trained in sending and receiving Morse code using innovative training materials (Mnemonics and guided practice). Two aptitude groups (High and Average) were compared on code learning and performance factors. The ASVAB and non-verbal tests (Visual Pattern Discrimination (VPD) and Visual
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20. ABSTRACT (cont.)

Reaction Time (VRT)) were used to predict performance. Mnemonics and guided practice proved superior to traditional training materials for learning Morse code. The type of training materials had no significant effect on ability to send and receive messages. The ASVAB tests used to select signalmen for training were good predictors for High aptitude individuals while the VPD proved the best predictor for the lowest quartile (as measured by word knowledge (WK) and arithmetical reasoning (AR) ASVAB subtests). Course attrition was discussed and a training model proposed for Navy Signalman training.

SUMMARY OF THE STUDY

A study was conducted to develop a selection model for the prediction of Signalman performance in sending and receiving Morse code and to evaluate several training strategies designed to enhance the learning of Morse code. The trainees were 180 Navy and Coast Guard enlisted males. Trainees were divided into four groups based on aptitude (High vs. Average) and instructional materials (traditional vs. innovative). The predictor battery for code acquisition consisted of age, education, and the WK, AR, AD, and MC subtests of the Armed Services Aptitude Battery (ASVAB). Non-verbal Visual Pattern Discrimination (VPD) and Visual Reaction Time (VRT) were used as predictors of performance in receiving and sending code.

In general, High aptitude personnel learned Morse code at a faster rate than Average aptitude personnel. However, while the innovative training strategies (guided practice, mnemonics) enhanced the learning of all trainees, the most significant gains were made by Average aptitude trainees (see section III of this report).

The High aptitude group also performed significantly better than the Average aptitude group in receiving code via flashing light even though both groups achieved criteria performance in the code acquisition phase of the study. This suggests that current training strategies do not sufficiently accommodate variations in trainee aptitudes.

The WK and AR subtests of the ASVAB, which are currently used for assignment to the Signalman course, are good predictors of acquisition of code and reception of code via flashing light. However, the non-verbal Visual Pattern Discrimination Test (VPD) proved to be the best predictor of performance via the flashing light for the lowest quartile of personnel (as measured by WK and AR subtests) (see section IV of this report).

A training model is proposed which would maximize performance for all aptitude groups. The following recommendations are made (see section V of this report):

- A Visual Pattern Discrimination test be added to the selection battery for screening of Average and Low aptitude individuals being considered for Signalman training.

- Self-paced instruction be adopted to accelerate training of High aptitude trainees and permit lower aptitude trainees time to attain task mastery.

- The Visual Pattern Discrimination exercise be used for orientation to code reception via flashing light.

- The validity of current entry requirements should be examined. This recommendation is based on the finding that waivered students utilized in this study performed successfully.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF ILLUSTRATIONS

SECTION I

INTRODUCTION

The Navy is searching for improved ways to (1) identify personnel with potential for specific occupations and (2) develop training strategies which will maximize individual capabilities. In order to devise suitable training strategies, individual aptitudes must be accounted for in the training design. The Navy currently uses verbally loaded aptitude tests as the principal predictors of trainability, and there has been a growing concern as to whether these tests accurately reflect an individual's potential for success in many Navy ratings. The research reported herein relates performance on verbal and nonverbal tests to performance in the training of a Morse code task for signalmen. The usefulness of these tests, along with individual background data, was evaluated in an effort to improve the selection and classification procedures currently in use for assigning Navy signalmen to training.

BACKGROUND

The study of Morse code learning has a history beginning with the classical study by Bryan and Harter (1897). The most extensive studies in code learning are probably those of Keller and his associates (1943-1945) which led to the development of the "Code Voice" method adopted by the War Department. The Navy modified this method and has periodically sought more efficient ways to teach Morse code to radiomen (Robins, 1958; Rulon & Brooks, 1960).

For the most part, research efforts have concentrated on the use of Morse code in auditory rather than visual communication as used by signalmen. Navy signalmen use Morse code to send messages via flashing light signals by manipulating a metal shutter-like device placed in front of a light source which emits light flashes of different duration to produce a series of dot-dash patterns. The series of dots and dashes represents letters and finally words and sentences which comprise a meaningful message.

Recently, Ainsworth (1979) studied the learning of Morse code by Navy signalmen. In that study, innovative strategies (mnemonics and guided learning and practice) were employed to enhance code learning. Mnemonics plus guided learning and practice was found to be a most effective strategy for increasing the general achievement level of trainees. The strategy virtually eliminated differences in code acquisition resulting from variations in aptitude level after 4 hours of practice. However, even though all trainees learned the code to criterion (after 6 hours of practice), there were significant differences in the follow-on performance phase (receiving Morse code via flashing light) attributable to aptitude levels as measured by the Armed Services Vocational Aptitude Battery (ASVAB) subtests which are used to assign individuals to signalman training. These paper and pencil tests measure a limited portion of an individual's abilities; namely, those implicit in verbal skills. Paper and pencil tests work quite well for selecting and training 60 to 70 percent of entering military personnel. For the remaining 30 to 40 percent (many of whom are average or below average in ability), these classification procedures are grossly inadequate and provide little information on how individuals may best be utilized.

While there is recognition that valid relationships may exist between aptitude test scores and success in the academic setting, the predictive relationship between these tests and actual job performance is less clear. With regard to signalman training, the staff has expressed concern that selection tests currently in use may not reliably predict speed and accuracy in receiving Morse code visually. These tests are apparently valid predictors of the completion of the cognitive portion of the training curriculum, but there is some doubt as to their effectiveness in predicting performance.

It is generally recognized that nonverbal measures are extremely valuable in providing information concerning an individual's capabilities. Non-verbal tests, when added to the selector aptitude indexes, add a significant and unique contribution to the prediction of technical training school success (Wiskoff, 1977; Anastasi, 1950; and Wilbourn, Quinn, and Leisey, 1976).

PURPOSE

The present study was designed to identify specific non-verbal individual factors which may account for the differential performance of various aptitude groups (trained to criteria in the Ainsworth (1979) study) in the reception of visual Morse code and to validate selection tests currently utilized for the assignment of signalmen.

ORGANIZATION OF THE REPORT

In addition to this introduction, the report contains four sections and five appendices. Section II contains a description of the study design, trainee population, the learning tasks, training materials, and study and analysis procedures. Section III summarizes the results of the study including performance differences between treatment groups, intercorrelations of the predictor and criteria variables, predictor models for each of the performance phases of the signalman course and final school grade, and course attrition. Section IV discusses the validation of the ASVAB subtests used for signalman selection, personnel characteristics related to the Morse code task, and course attrition. An instructional model for signalman training is provided. Section V provides conclusions and recommendations for course managers.

Appendix A contains a description of the Armed Services Vocational Aptitude Battery with corresponding reliability coefficients. The types of training materials used in the study are described in appendix B. Appendix C is a copy of the pattern discrimination exercise instructions given to the staff and trainees. Appendix D contains the Analysis of Variance Source Tables. The statistical data are discussed in appendix E.

SECTION II

STUDY DESIGN

This section contains a description of the study design, trainee population, learning tasks, and study procedures.

The study was designed to assess the differential effects of aptitude levels, type of training materials, and amount of practice time on receiving Morse code messages via flashing light at five words per minute. Trainees were divided into two groups of High and Average aptitude, with the High aptitude trainees having a combined WK + AR score of 115 or greater on the ASVAB and the Average trainees having a combined WK + AR score of less than 115. The cutoff score on the ASVAB was arbitrarily chosen at 115 because it is approximately 1 standard deviation above the normalized, composite mean of 100. Four types of training materials were employed for the code acquisition. These are discussed in detail later in this section. For the performance phase, the length of practice training was 4 and 5 weeks in receiving coded messages via a mechanically operated, tape-driven flashing light apparatus.

TRAINEES

The trainees were 180 Navy and Coast Guard enlisted males with a mean age of 19.5 years (range 17-30) and a mean of 11.8 years of formal education (range 9-16). Academic ability was measured by the ASVAB which is administered to each new military accession. A General Technical Composite score was obtained by summing the scores on two subtests, Word Knowledge (WK) and Arithmetic Reasoning (AR). Each subtest has been normalized to a mean of 50 and a standard deviation of 10. The WK and AR composite mean is 100 and the standard deviation of the composite scores is 15. (Appendix A contains a list of subtests with corresponding reliability coefficients.) The WK and AR composite scores of the study group ranged from 99 to 143. It can be inferred that the trainees were average and above average in general intelligence. A composite WK and AR score of 105 is required for entry into the signalman school. Occasionally waivers are given, depending upon billet requirements and human resources supply.

All trainees included in the analyses completed the 6-week Signalman "A" School at the Service School Command, Naval Training Center, Orlando, Florida. Twelve consecutive classes were used, with a new class convening every other week.

THE LEARNING TASKS

The learning tasks were (1) the acquisition of the International Morse Code and (2) sending and receiving code via flashing light. The code consists of 42 sight patterns which include 26 letters, 10 numerals, and 6 punctuation marks. A 100 percent understanding of the code is essential for effective communication utilizing flashing light. In the acquisition training phase, the trainee must learn the patterns, the alphabetic equivalent, and the

phonetic equivalent (b=bravo) since s/he must perceive the code, interpret, and verbally relay the message to a "copier." In performance, the trainee must send and receive code via flashing light; i.e., recognize the letters and form a message.

TRAINING MATERIALS

The training materials used in this study were developed by Aagard and Braby (1976). These materials were formatted in four ways. Table B-1 in appendix B depicts the four formats with respect to their learning guideline content. Traditionally, training materials for Morse code have included printed lists of the code and its alphanumeric meanings (lists are printed on a student guide, on a hand-held cardboard flasher, and on flash cards) and printed lists of opposite codes (such as .- for A and -. for N) and similar codes (such as . for E and .. for I, - for T and -- for M). Trainees have traditionally learned the code using self-generated learning strategies. One group of trainees learned the code using the traditional (Type 1) materials.

The second group of trainees was given a handbook with the proceduralized learning technique of chunking (or part learning), guided practice, intermittent feedback, and self-tests (Type 2 materials). Memory aids were not provided, so the 42 paired-associates were typically rote-memorized.

Group 3 trainees were given a 13-page handbook presenting Morse code symbols in six sets (Type 3 materials). There were no practice exercises or self-tests, and there were no combined exercises or criterion tests. Memory aids were provided. The handbook proceduralized the learning technique of verbal-pictorial mediation but did not involve chunking, guided practice, or intermittent feedback.

Group 4 trainees were given a booklet utilizing the principles used in booklets 2 and 3, mnemonics, chunking, guided learning and practice, and a self-test. The 137-page handbook proceduralized chunking, guided practice, and intermittent feedback as well as verbal-pictorial mediation (Type 4 materials).

PROCEDURE

ACQUISITION PHASE. The study was conducted in the operational environment where it is often difficult to exercise the same rigid controls that are possible in the experimental laboratory. For this reason, a controlled study period was incorporated into the design. Training materials were distributed and three 2-hour study periods were conducted with the experimenter closely observing trainee behavior. Trainees were not permitted to take their training materials with them from the classroom. All trainees were given a pretest the first day of class to determine prior knowledge of Morse code. Trainees having previously learned portions of the code were eliminated from the data analysis. Trainees were assigned to treatment groups on the basis of aptitude. A two-way split was made with the High aptitude group having a combined WK + AR score greater than 115 and the Average aptitude group having a combined WK + AR score of less than 115. The subjects falling in the Average category were of average intelligence when compared with recruits whose scores did not qualify them for entry into the course.

PERFORMANCE PHASE. Prior to entry into class, trainees were administered a Visual Pattern Discrimination (VPD) test, and Visual Reaction Time (VRT) measures were taken. It was explained that these were related to the task of receiving code via flashing light later in the course and were being used to determine those persons requiring special assistance.

The VPD test consisting of meaningless dots and dashes was group administered to each class to ensure standardization across groups. The flashing light signal was delivered by a time-punched tape which drove the light source. The short bursts of light could be identified as dots and dashes depending upon the duration of the light signal. The test consisted of 27 sets (including two practice sets) of randomized dots and dashes (six bits each set, the average length of a coded letter). The presentation rate was at five words per minute (the speed at which trainees are expected to read code at the end of 6 weeks). Trainees were instructed to repeat the pattern of dots and dashes on their answer sheets as they identified the patterns. Meaningfulness of the pattern was not an issue.

Reaction time to a visual stimulus was taken prior to the beginning of classes. Trainees were instructed as to the purpose of the test and the relationship of the procedure to receiving code visually. The VRT apparatus was housed in two separate rooms and two experimenters were required. One experimenter instructed the trainee on the response mechanism, the other presented the stimuli. Stimulus presentation was randomized at 8 to 10 second intervals. The apparatus consisted of an energy source, a 15 watt bulb with a red glass plate covering, an experimenter button to trigger the light stimulus, a telegraph key for trainee response to the light stimulus, and a clock for measuring response time in 1/100 of a second. A series of 13 stimuli were administered to include three practice trials. For scoring purposes, the average of the 10 trials was used.

DATA COLLECTION

The instructor of each class introduced the trainees to code transmission via a flashing light during the second week of training. Video tapes were used to help trainees transition from "receiving" on paper to receiving via flashing light. Sight patterns (with brief bursts of light representing a series of dots and dashes) were presented at slow rates of speed. Each series represented a letter of the alphabet. Following the video tape exercises, the trainees practiced with a mechanically operated flashing light in the classroom.

Each instructor gave the fourth and fifth week flashing light tests by using a tape-driven, mechanically operated apparatus. This apparatus ensured that all encoded messages were sent at five words per minute. Two specially made tapes, one for each week, ensured that all letters, numbers, and punctuation marks were given in the same manner to all classes (i.e., in 20 groups of 5 characters per group--16 letter groups, 2 number groups, and 2 punctuation mark groups). The task was one of decoding; i.e., the trainee had to recognize that .- stood for A. The maximum possible score on each performance test was 100.

The sixth week of training (the results of which are included in the regression analysis) was designed to familiarize trainees with a hand-operated, 12-inch incandescent search light--the type used aboard ship to communicate. Trainees used this light to communicate among themselves while outside on simulated ship bridges. During this practical phase of training, instructors emphasized the development of good communication procedures. The sixth week examination was a combination of flashing light and flag semaphore code reception.

ANALYSES

An Analysis of Variance (ANOVA) was performed on the acquisition data to determine the effects of aptitude and type of instructional materials on learning to "send" and "receive" (paper and pencil test) Morse code. ANOVA source tables are included as appendix D.

Performance data was first analyzed to determine whether there were any significant differences in performance due to treatment effects during the acquisition phase; then a step-wise multiple regression analysis was used to determine the degree to which the psychological predictor variables and the performance variables were interrelated and could be combined in a predictor model. A step-wise, rather than a canonical correlation, procedure was used since the study was of an experimental nature, and the step-wise procedure provided better capability for examining the impact of each variable. In multiple regression analysis, one dependent variable is partitioned from the rest of the matrix, while in canonical correlation analysis, two or more dependent variables are partitioned from the rest of the matrix. For purposes of this study, it was considered essential to determine the impact of each variable separately since strategies would be considered for each phase in the learning process based on trainee performance at each point in the cycle.

The ANOVA was used to determine the differential effects of aptitude levels and amount of practice on flashing light performance (i.e., receiving messages at five words per minute). The Newman-Kuels procedure was used to determine the significance of the difference between means. To determine the strength of the association between treatment and scores obtained by the trainees in both the acquisition and performance phases of the course, eta squared was computed. This statistical data is discussed in appendix E. The study results follow.

SECTION III

RESULTS

This section reports the results of the data analyses. First, the results of the analysis of performance data for training weeks four and five are presented. Next, a description is given of trainee mean scores on the predictor (aptitude) variables followed by the intercorrelations of the predictor and criteria (performance) variables and the correlations between these variables. The results of the regression analysis are given in the form of regression coefficients for each best four-variable predictor model developed for each performance test (including week six) and Final School Grade (FSG). Regression equations were computed for each best four-variable predictor model. Expectancy tables have been developed from the raw data showing the relationship between the best four-variable models, the currently used two-variable model, and the criteria variables. The section concludes with a comparison of predictor variable scores for trainees who completed the course, those who were set-back, and those who failed to complete the course.

The major emphasis of this study was on the performance phase of the signalman task. The acquisition data were obtained by Ainsworth (1979) and are summarized here for the purpose of clarity and convenience of the reader. More detail on code acquisition can be found in Ainsworth (1979).

ACQUISITION PHASE

The analysis showed that aptitude significantly affects learning to "send" paper and pencil test Morse code ($\underline{p} < .0001$). Relevant statistical tables are provided in appendix D. When only aptitude was considered, High aptitude trainees performed significantly better than Average aptitude trainees. The type of instructional material also significantly affected learning to "send" Morse code ($\underline{p} < .0001$). When aptitude was disregarded, trainees who studied with the two handbooks containing memory aids in the form of mnemonics performed better than those who studied without the memory aids. Trainees who used the handbooks containing guided learning and practice plus memory aids performed significantly better ($\underline{p} < .01$) than trainees who used the traditional or guided learning and practice only materials. Trainees who used the guided learning and practice only handbooks performed significantly better than trainees who studied with traditional materials ($\underline{p} < .01$). The amount of study time (2,4, and 6 hours) significantly affected the ability to "send" code ($\underline{p} < .0001$); i.e., the mean scores for all experimental groups except Average aptitude, traditional materials, approached the limit of the test (42 points) after 4 hours of study. The mean score for all trainees at the end of 6 hours of study was 40.7. All treatment groups had essentially mastered the code after 6 hours of study.

Aptitude significantly affected ability to learn to "receive" Morse code on paper ($\underline{p} < .0001$). High aptitude trainees performed significantly better than Average aptitude trainees. Type of instructional material also affected learning to "receive" code ($\underline{p} < .0001$). Trainees using the guided learning and practice plus memory aids performed significantly better ($\underline{p} < .01$) than those using traditional materials. The amount of study time significantly affected

"receiving" ability ($p < .0001$). The mean scores of all groups approached the limit of the test (42) after 6 hours of study.

PERFORMANCE PHASE

The results showed that academic ability (as measured by the WK and AR ASVAB subtests) significantly affects the ability to receive flashing light messages. High aptitude trainees performed significantly better than Average aptitude trainees ($p < .001$). Type of instructional material used during acquisition did not significantly affect the reception of Morse code via flashing light. There were no significant differences in trainee performance across treatment groups. As expected, flashing light test scores improved from one week of training to the next. The basic performance data are depicted in figure 1.

CORRELATIONS BETWEEN VARIABLES

The major emphasis of this study phase was on the relationship of predictor (aptitude) variables to (1) accuracy of signalman trainees in receiving Morse code visually and (2) FSG. The predictor variables included trainee scores on subtests of the ASVAB, WK, AR, Attention to Detail (AD), Mechanical Comprehension (MC) subtests, Education (ED), Age, VPD, and VRT. The criteria variables were three flashing light performance tests (FL 1, 2, and 3) and FSG. The third examination combines reception of code via flashing light and semaphore flag learning. It was added to the criteria variables at this point in the study to provide a more complete picture of the total performance task. The mean, standard deviations, and range of the predictor variables are provided in table 1.

TABLE 1. MEAN, STANDARD DEVIATION, AND RANGE OF TRAINEE SCORES ON PREDICTOR VARIABLES

Variable	Mean	Standard Deviation	Range
Word Knowledge	60.06	7.08	44-74
Arithmetical Reasoning	55.80	6.10	37-70
Attention to Detail	52.88	8.75	30-70
Mechanical	50.99	7.98	31-73
Education	11.81	1.33	9-16
Age	20.80	2.58	17-30
VPD	10.40	3.50	02-20
Visual Reaction Time (100ths of a second)	25.63	3.43	20-54

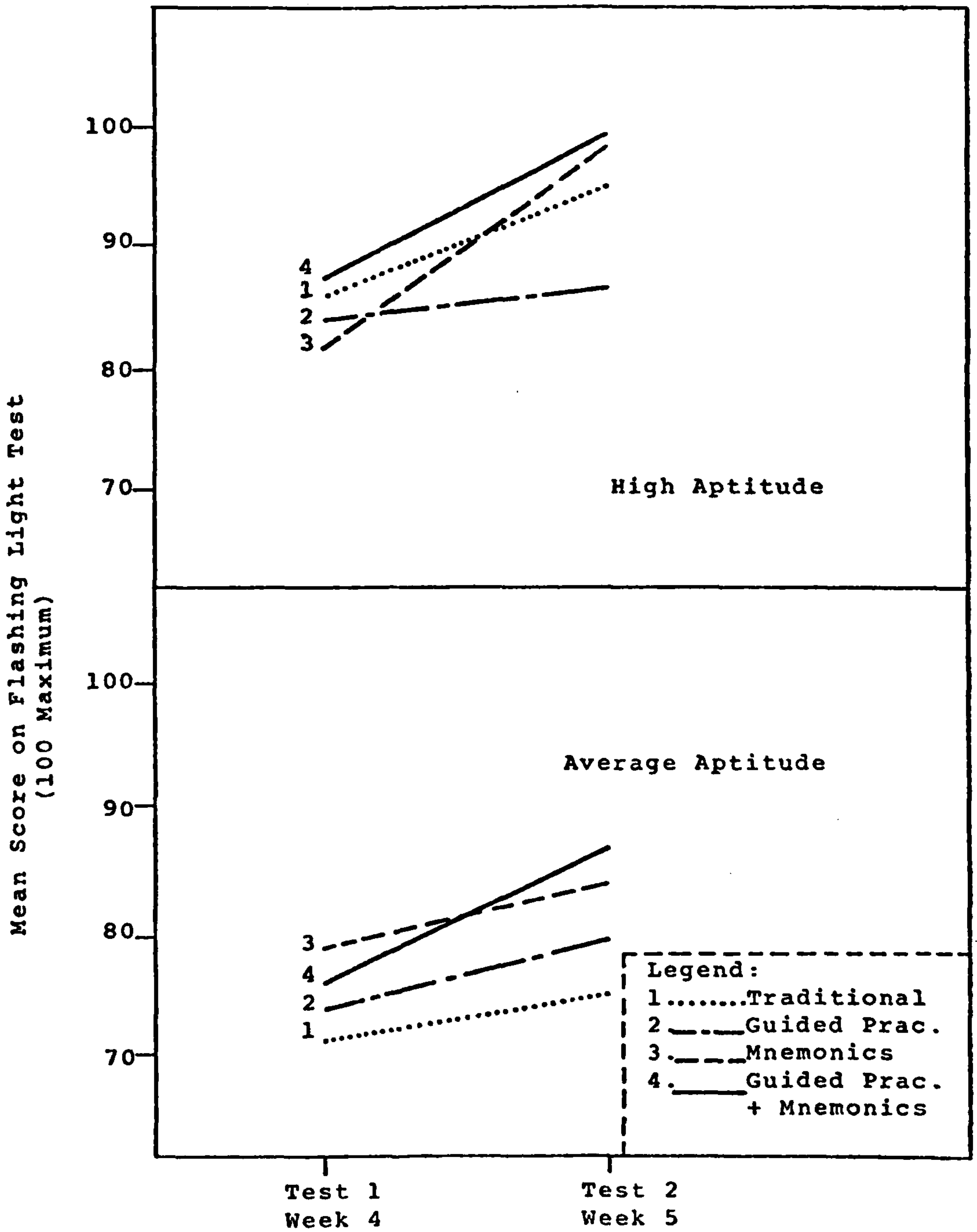

Figure 1. Performance Curves for Two-Aptitude/Four-Treatment Groups on Flashing Light Tests

The mean ASVAB scores of the total trainee group all fell above the mean (50) indicating that the population was of average or above average intelligence. The mean score on the VPD test was 10 (out of a possible 25), with a range of 2-20. The mean VRT score was .26 seconds, ranging from .20-.54 seconds.

The intercorrelations between the predictor and criteria variables are presented in table 2. The majority of the correlations obtained were significant at the .01 level; those which were not have been underlined.

PREDICTOR INTERCORRELATIONS

The ASVAB WK scores were correlated significantly and positively with other predictor variables except for VRT and Age. Visual Reaction Time correlated negatively and nonsignificantly while Age correlated negatively and significantly. This indicates some degree of commonality; i.e., the WK test measures some of the same factors measured by the other predictor instruments.

Like WK, AR was positively and significantly correlated with the majority of the predictor variables. The two exceptions were VRT and Age which were negative and insignificant. Attention to Detail was positively and significantly correlated with WK and AR, .31 and .20, respectively. There were no other significant correlations. The correlations indicate some commonality of factors between the AD subtest and the WK and AR tests. The highest correlation obtained for MC was with AR (.43). Mechanical Comprehension was moderately, but significantly, correlated with WK (.24), VPD (.27), and VRT (-.16).

Visual Pattern Discrimination was positively and significantly correlated with MC (.27), WK (.23), and AR (.18) again, indicating some commonality between these measures. Visual Reaction Time apparently measures a factor not measured by the other predictor tests. Visual Reaction Time was positively correlated with MC (.16) which was no surprise. No other significant correlations were obtained for VRT.

CRITERIA INTERCORRELATIONS

Intercorrelations between the three flashing light tests were high and positive; those between flashing light tests 1 and 2 and "send" (S3) and "receive" (R3) paper and pencil tests were moderate, but significant. No significant correlation existed for FL3 and the final "send" and "receive" tests. Apparently, factors other than Morse code knowledge weigh heavily in that test--semaphore code, for example.

Final School Grade correlations were highly significant with the three flashing light tests, the highest (.65) with FL1. This indicated that these tests measure a source of variance which makes up a significant part of the variance in the final grade; therefore, any variable which can predict flashing light performance early in the course would be an asset to the instructor for applying training strategies. Final School Grade was correlated moderately and positively with the final acquisition "send" and "receive" scores, .35 and .49, respectively.

TABLE 2. CORRELATION COEFFICIENTS OF PREDICTOR AND CRITERIA VARIABLES

	WK	AR	AD	MC	ED	Age	VPD	VRT	FL1	FL2	FL3	FSG	S3*	R3*
WK	1.00													
AR	.26	1.00												
AD	.31	.30	1.00											
MC	.24	.43	.11	1.00										
ED	.47	.22	.11	.13	1.00									
Age	-.38	-.03	-.11	.12	-.48	1.00								
VPD	.23	.18	.07	.27	.13	.04	1.00							
VRT	-.03	-.10	-.12	-.16	.05	.02	.02	1.00						
FL1	.30	.31	.26	.16	.17	.01	.24	-.10	1.00					
FL2	.24	.30	.27	.19	.03	.04	.27	-.16	.66	1.00				
FL3	.28	.31	.18	.30	.14	-.00	.07	-.21	.49	.53	1.00			
FSG	.54	.54	.33	.36	.41	.09	.28	-.10	.65	.52	.46	1.00		
S3*	.24	.18	.15	.17	.11	.05	.07	-.06	.18	.21	.02	.35	1.00	
R3*	.30	.30	.20	.19	.11	-.01	.12	-.14	.25	.26	.11	.49	.80	1.00

*Send, receive, paper and pencil tests

CORRELATIONS BETWEEN PREDICTOR AND CRITERIA VARIABLES

Correlations between the ASVAB WK, AR, AD, and MC variables and performance flashing light test scores were positive and significant as were those between the ASVAB tests and the final "send" and "receive" test scores. For prediction purposes, this indicated that trainees who do well on the predictor tests should succeed in the course. It further indicated that the cognitive factors measured by the WK, AR subtests weigh heavily in the ability to receive code via flashing light. The AD subtest measures attention to detail. The moderate, positive correlation with flashing light tests indicates that the same close attention which is required in clerical procedures is important in receiving code visually. This, in essence, is a measure of the attentive processes identified by information processing theorists.

Visual Pattern Discrimination was correlated significantly with scores on flashing light tests 1 and 2, but not correlated with FL3. This indicated that some factor other than the spatial factor measured by VPD was included in the FL3 test score. The test consisted of receiving code via flashing light with a hand operated flashing light in a simulated shipboard environment and receiving code via semaphore flags.

Visual Reaction Time was significantly and negatively correlated with FL2 and FL3 and the final "receive" test scores. The negative correlation indicated that trainees who have a faster reaction time are better in receiving flashing light messages. Each of the criteria tests was timed and this could account in part for the relationship of VRT and the criteria tests.

Final School Grades were significantly correlated with all predictor variables except VRT and Age. WK and AR had the highest correlation with FSG, .54 in each instance. This indicated that the cognitive factors measured by these subtests weigh heavily in the final grade composite.

PREDICTION OF PERFORMANCE AND FINAL SCHOOL GRADE BY REGRESSION ANALYSIS

Predictor models were developed using the step-wise multiple regression procedure. The best four-variable model obtained for performance and FSG for the total sample is presented here for comparison purposes along with the two-variable model currently in use. A separate regression procedure was used to develop predictor models for the bottom one-quarter of the trainees based on aptitude. These models are also presented. The variables' multiple R values were generated as part of the step-wise multiple regression procedure.

FLASHING LIGHT TEST NO. 1. Table 3 shows the standard error regression coefficients and percent variance accounted for by each of the variables in the best four-variable model for performance test FL1 for the total sample.

TABLE 3. REGRESSION COEFFICIENTS OF THE FOUR-VARIABLE MODEL PERFORMANCE FLASHING LIGHT TEST (FL1)*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
WK	0.578	0.456	9.1
AR	0.587	0.460	4.7
VPD	3.172	0.454	1.9
AGE	1.524	0.524	1.1
		TOTAL	16.8

Y_2- intercept = -8.94
R^2 = .178
R = .421
*Significance level for model entry $\underline{p} =< .10$

The multiple regression equation for FL1 based on the best four-variable model is:

$$FL1 = 0.46\ (WK) + 0.46\ (AR) + 0.45\ (VPD) + 0.52\ (AGE) - 8.94$$

By comparison, using FL1 data for the two-variable model currently in use, WK was found to account for 9 percent and AR for 6 percent, for a total of 15 percent.

FLASHING LIGHT TEST NO. 2. Table 4 shows the standard error, regression coefficients, and percent variance accounted for by each of the variables in the best four-variable model for performance test FL2.

TABLE 4. REGRESSION COEFFICIENTS OF THE FOUR-VARIABLE MODEL PERFORMANCE FLASHING LIGHT TEST (FL2)*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
WK	0.133	0.430	8.3
AR	0.137	0.389	5.4
VPD	0.239	0.533	3.0
ED	0.691	-1.500	2.9
		TOTAL	19.6

Y_2- intercept = 50.17
R^2 = .195
R = .442
*Significance level for model entry $p = < .10$

The multiple regression equation for FL2 based on the best four-variable model is:

$$FL2 = 0.43\,(WK) + 0.39\,(AR) + 0.53\,(VPD) - 1.50\,(ED) + 50.17$$

By comparison, using FL2 data for the two-variable model, WK was found to account for 8 percent and AR for 5 percent, for a total of 13 percent.

FLASHING LIGHT TEST NO. 3. Table 5 shows the standard error regression coefficients and percent variance accounted for by each of the variables in the best four-variable model for performance test FL3.

TABLE 5. REGRESSION COEFFICIENTS OF THE FOUR-VARIABLE MODEL PERFORMANCE FLASHING LIGHT TEST (FL3)*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
WK	0.106	0.220	10.7
MC	0.104	0.174	4.9
AR	0.134	0.318	3.8
VRT	0.207	-0.413	3.2
		TOTAL	22.6

Y_2- Intercept = 58.63
R^2 = .193
R = .440
*Significance level for model entry $\underline{p} = < .10$

The multiple regression equation for FL3 based on the best four-variable model is:

$$FL3 = .22\ (WK) + .17\ (MC) + .32\ (AR) - .41\ (VRT) + 58.63$$

By comparison, using FL3 data for the two-variable model, AR was found to account for 11 percent and WK for 4 percent, for a total 15 percent of the variance.

FINAL SCHOOL GRADE. Table 6 shows the standard error, regression coefficients, and percent variance accounted for by each of the variables in the best four-variable model for FSG.

TABLE 6. REGRESSION COEFFICIENTS OF THE FOUR-VARIABLE MODEL FINAL SCHOOL GRADE (FSG)*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
WK	0.578	3.528	29.6
AR	0.587	3.392	15.7
ED	3.172	9.413	3.4
AGE	1.524	4.686	1.7
		TOTAL	50.4

Y_2- Intercept = 107.18
R^2 = .503
R= .709
*Significance level for model entry p =< .10

The multiple regression equation for FSG based on the above four-variable model is:

$$FSG = 3.53\ (WK) + 3.39\ (AR) + 9.41\ (ED) + 4.69\ (AGE) + 107.18$$

PREDICTION OF PERFORMANCE AND FINAL SCHOOL GRADE FOR BOTTOM ONE-FOURTH APTITUDE GROUP

A continuing problem is the optimization of training for marginal, low-aptitude personnel. While none of the individuals in this study were marginal, it was expected that an analysis of the performance of individuals in the lowest quarter of the aptitude scale would produce valuable information. Improved methods for the selection and training of these individuals would make it possible to utilize individuals not presently considered for this course.

For the total sample (high and average aptitude groups combined), the ASVAB, WK, and AR accounted for the major portion of the variance. However, these test scores were not sufficiently significant to enter the four-variable model for the lower aptitude group. Visual Pattern Discrimination accounted for the major portion of the variance for this group of trainees for both initial performance and FSG.

Table 7 shows the standard error regression coefficients and percent variance accounted for by each variable in the best four-variable model for the first flashing light performance test for the bottom quarter of the sample based on combined WK + AR scores.

TABLE 7. REGRESSION COEFFICIENTS OF THE FOUR-VARIABLE MODEL PERFORMANCE TEST (FL1) FOR BOTTOM 25 PERCENT, COMBINED WK + AR SCORES*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
VPD	0.759	1.243	4.5
AD	0.324	0.367	2.5
MC	0.222	0.218	2.5
AGE	0.802	0.785	2.8
		TOTAL	12.3

Y- Intercept = 18.93
$R^2 = .121$
R = .348
*Significance level for model entry $p = < .10$

Using the FL1 data for the lowest quarter aptitude group, VPD was found to account for 5 percent of the total variance, AD for 2 percent, MC for 2 percent, and Age for 3 percent, for a total of 12 percent.

The multiple regression equation for FL1 based on the best four-variable model is:

$$FL1 = 1.24\ (VPD) + .37\ (AD) + .22\ (MC) + .78\ (AGE) + 18.93$$

Table 8 shows the standard error regression coefficients and percent variance accounted for by each variable in the best four-variable model for FSG for the bottom quarter of the sample (based on combined WK + AR scores).

TABLE 8. REGRESSION COEFFICIENTS OF THE FOUR-VARIBLE MODEL, FINAL SCHOOL GRADE FOR BOTTOM 25 PERCENT, COMBINED WK + AR SCORES*

Variable	Standard Error	Beta Coefficients	% Variance Accounted for
VPD	2.319	3.948	12.9
AD	0.798	0.916	10.3
ED	7.396	16.649	6.2
AGE	2.667	6.953	2.9
		TOTAL	32.3

Y- Intercept = 154.19
R^2 = .321
R = .567
*Significance level for model entry $\underline{p} = < .10$

Using the FSG data for the lowest quarter aptitude group, VPD was found to account for 13 percent of the total variance, AD for 10 percent, ED for 6 percent, and Age for 3 percent, for a total of 32 percent.

The multiple regression equation for FSG based on the best four-variable model is:

$$FSG = 3.95\ (VPD) + .92\ (AD) + 16.65\ (ED) + 6.95\ (AGE) + 154.20$$

It should be noted for performance FL1 that for the total sample WK and AR accounted for the major portion of the variance (14 percent) followed by VPD and Age (3 percent); whereas, for the lowest quarter aptitude group, VPD and AD accounted for the major portion of the variance (7 percent) followed by MC and Age (5 percent). No other variables entered the model at the .10 level of significance. For FSG for the lowest aptitude group, VPD and AD accounted for the major portion of the variance (23 percent) followed by ED and Age (9 percent); while, for the total sample, WK and AR accounted for the major portion of the variance (45 percent) followed by ED and Age (5 percent). VPD appears to be a better predictor of performance and FSG for lower aptitude persons than the ASVAB WK and AR subtests.

ESTIMATE OF SHRINKAGE FOR MULTIPLE CORRELATIONS

The sample of trainees employed in this study was a preselected group based on previously administered ASVAB scores. One would expect the R in the second sample to be smaller because of sampling error. To obtain an unbiased estimate of predictor validity for future samples (i.e., selected from the total available population), a cross-validation procedure was employed. The sample population was split into two subsamples containing approximately two-thirds and one-third of the total sample. This was done by random selection

of 7 and 13 from each cell of 20. Regression equations were computed for each of the "best" four-variable models predicting FL1, 2, and 3 and FSG. The regression equations computed using the two-thirds subsample were used to predict scores on a holdout group. The predicted scores were then correlated with actual scores obtained by individuals in the one-third holdout group. The correlations were: .43 for FL1, .38 for FL2, .29 for FL3, and .36 for FSG. In comparison, the correlations for the total group were .42 for FL1, .44 for FL2, .44 for FL3, and .70 for FSG. Each of the cross-validation correlations was significant at greater than the .01 level indicating that the predictive data can be applied to the general Navy signalman population with a reasonable degree of confidence.

RELATIONSHIP OF PREDICTOR AND CRITERIA VARIABLES-EXPECTANCY TABLES

Expectancy charts were developed from the raw data; i.e., the "regular" method described in Guilford (1956) to show relationships between the predictor and criteria variables. The criterion for passing the flashing light tests is 80 percent.

FLASHING LIGHT TEST NO. 1. Figure 2 is an expectancy chart showing the percentage of trainees who were successful in achieving the performance (FL1) criterion at each level of the combined ASVAB (WK + AR) scores. It will be noted that of the 23 trainees with ASVAB scores below the cutoff point for entry into the course, 78 percent failed to achieve the 80 percent necessary to pass the test.

Figure 3 is an expectancy chart showing the percent of trainees who could be expected to receive a passing score (80 percent) on performance test FL1 at each level of predictor scores. The best four-variable model (combined WK + AR + VPD + Age) was used to derive percent of successful trainees at each aptitude level. Ninety-two percent of the trainees selected will achieve a passing score if trainees having a combined score of 150 and above on the predictor criteria are selected.

FLASHING LIGHT TEST NO. 2. Figure 4 is an expectancy chart showing the percentage of trainees who were successful in achieving the 80 percent criterion (FL1) for each level of the ASVAB (WK + AR) scores. Note that 43 percent of those with scores below the selection cutoff score (105) failed to meet the criterion.

Figure 5 is an expectancy chart showing the relationship between trainee scores on the best four-variable model and performance (FL2) scores. Individuals having a combined score of 110 or above can be expected to attain the course criterion level of 80 percent.

FINAL SCHOOL GRADE. The criterion level for passing the course is an FSG of 75 percent. Data were analyzed to determine the relationship of FSG to the derived four-variable model (WK + AR + ED + Age) and the presently used two-variable model (WK + AR). Expectancy charts were developed and are shown in figures 6 and 7. Figure 6 shows that, based on the current two-variable model, 4 percent (one trainee) of those who remained in the course up to graduation failed; however, 96 percent of those who were predicted to fail actually achieved the criterion of 75 percent for passing the course. Figure

7 shows the mean FSG expected for trainees categorized according to combined predictor scores (four-variable model).

COMPARISON OF ATTRITES AND NON-ATTRITES

To better understand course attrition factors, data were analyzed to compare trainees who completed the course with those who were set back to repeat phases of the course and those who failed to complete the course. Only those who completed the course were included in the analysis of main instructional effects; i.e., 160 trainees.

The passing FSG for the course is 75 percent. The number of possible total points is 1,000. The minimum ASVAB combination for entry into the course is 105. Depending upon the needs of the Navy, trainees may receive waivers to enter the course. Of the 180 trainees in the total sample, 30 had ASVAB WK + AR scores below the 105 cutoff score. Of these 30 trainees, 27 percent failed to complete the course. Of those trainees with ASVAB scores between 105 and 120, 13 percent failed to complete the course. Table 9 shows a comparison of means for the three groups on the predictor variables. The three groups did not significantly differ from each other although the setbacks and attrites tended to have slightly lower scores on the predictor variables. Of the total population of 180 trainees, 12 percent (26) were set back to repeat one or more phases of the course, and 11 percent (20) failed to complete the course. Figure 8 shows the relationship between ASVAB (WK + AR) scores and failure to complete the course.

TABLE 9. COMPARISON OF MEANS FOR THREE GROUPS OF TRAINEES ON PREDICTOR VARIABLES

	No Attrite Group (N=160)	Setback Group (N=26)	Attrite Group (N=20)
WK	60.07	57.38	56.80
AR	55.80	55.73	52.20
AD	52.88	50.35	49.60
MC	50.98	50.65	49.66
ED	11.81	11.12	11.13
AGE	21.17	20.12	20.40
VPD	10.40	8.79	9.89
VRT	25.63	27.03	25.20

(N.S. $\underline{p} < .01$)

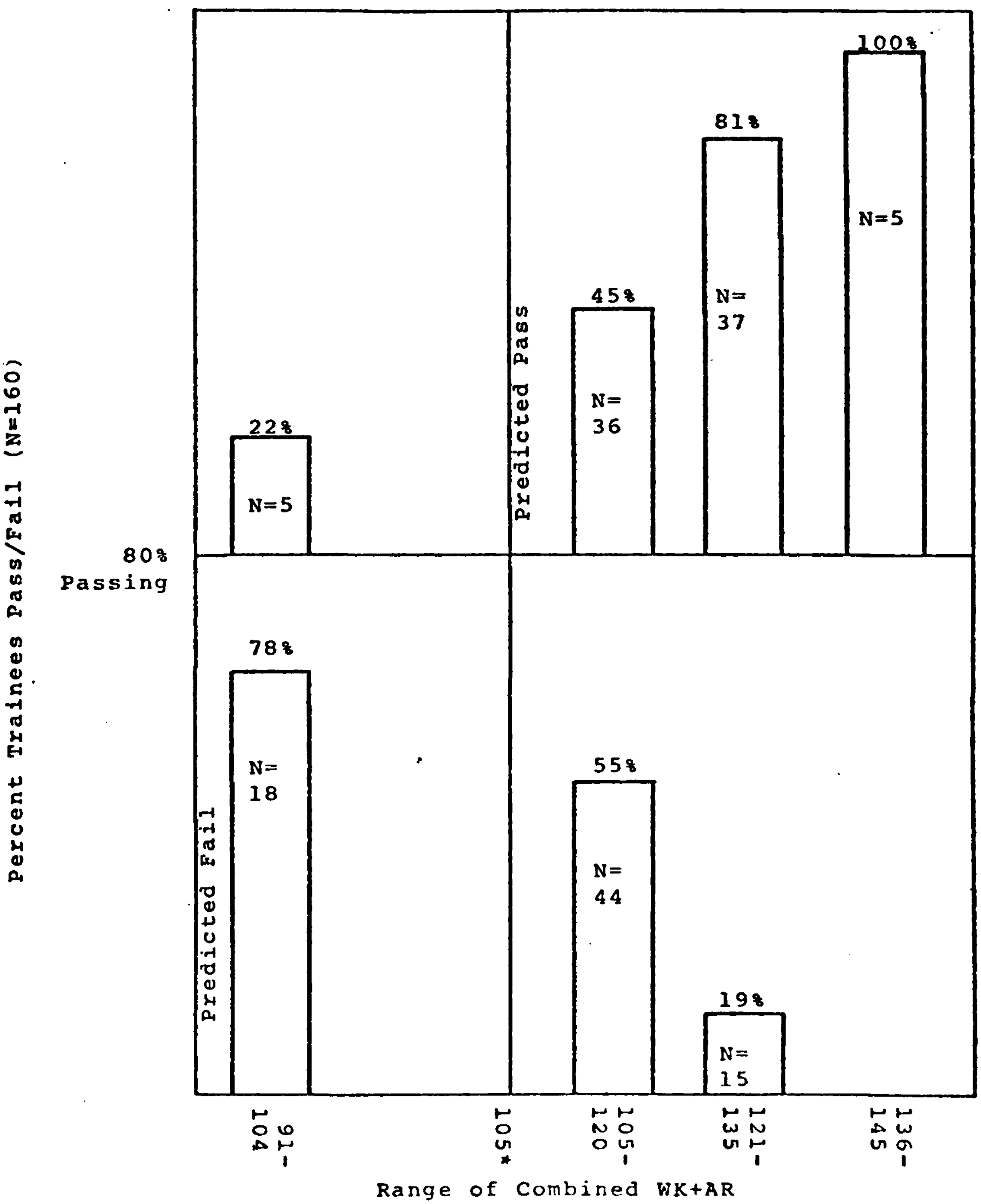

Figure 2. Expectancy Chart Showing Relationship Between Score Made on ASVAB (WK+AR) and Performance (FL1) for Signalman Trainees

*Minimum ASVAB for course entry

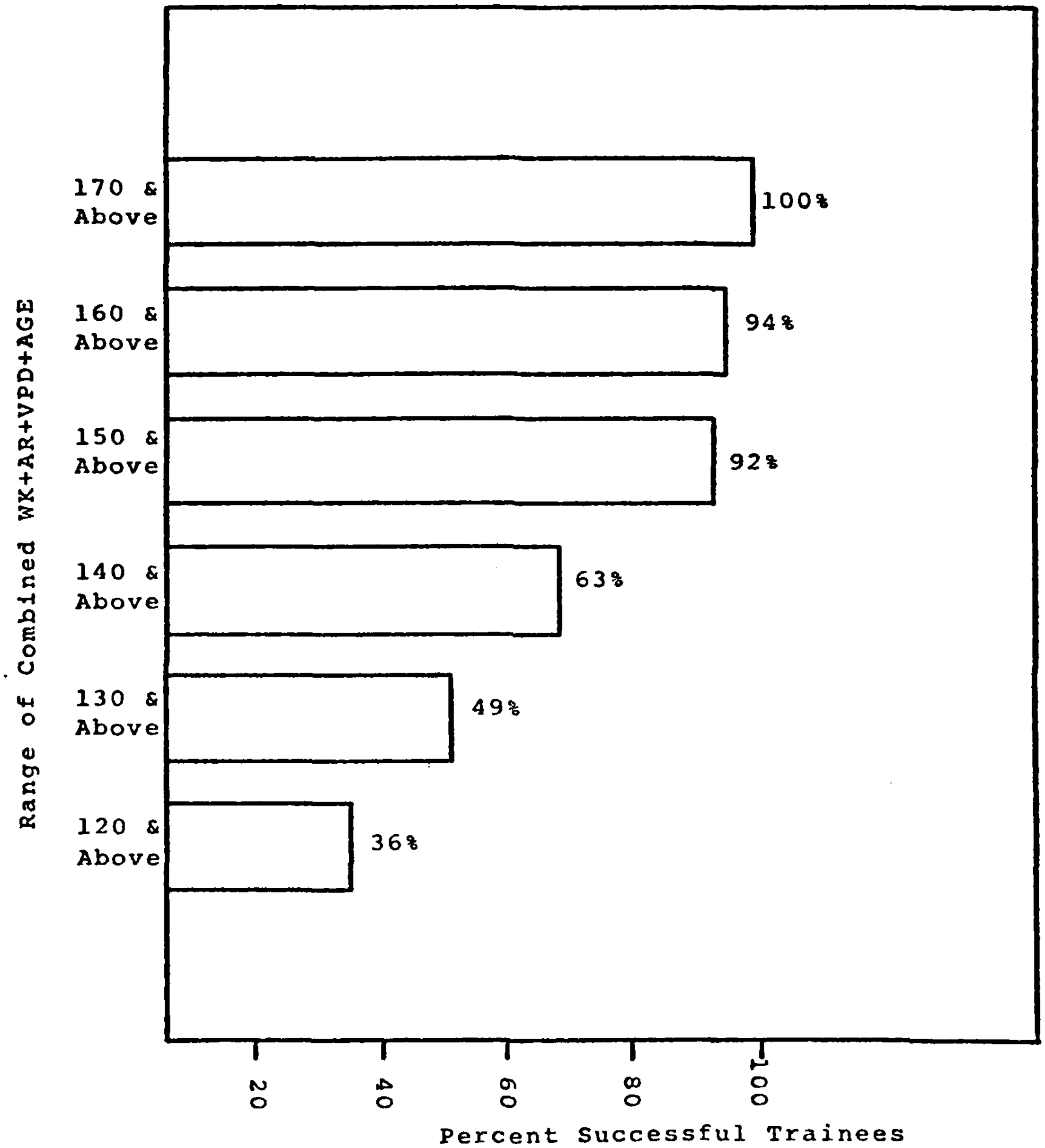

Figure 3. Expectancy Chart Showing Percent of Trainees Expected to be Successful (80 Percent Criterion) on Performance (FL1) at Each Level of Predictor Scores Based on Best Four-Variable Model

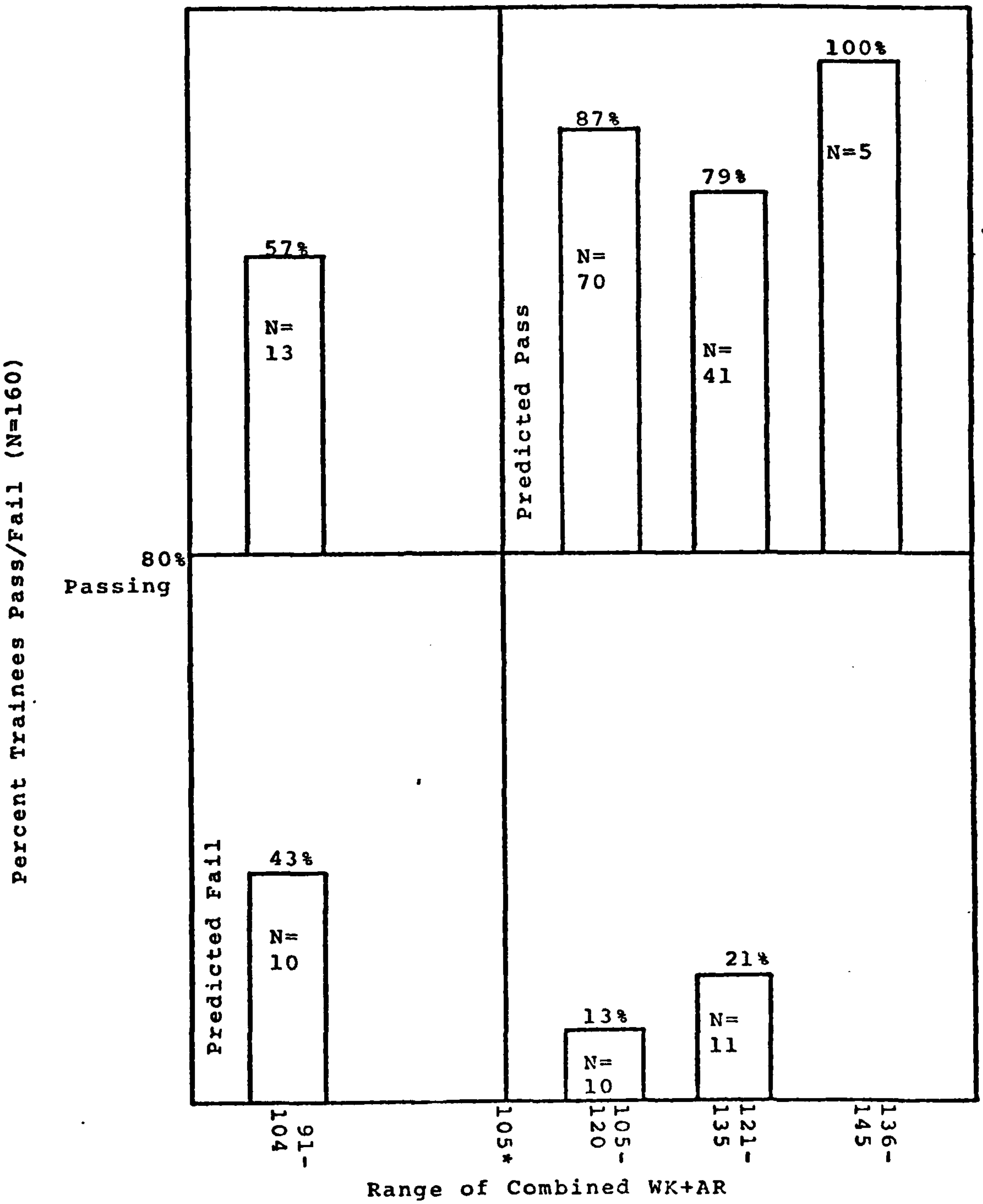

Figure 4. Expectancy Chart Showing Relationship Between Score Made on ASVAB (WK+AR) and Performance (FL2) Scores for Signalman Trainees

*Minimum ASVAB for course entry.

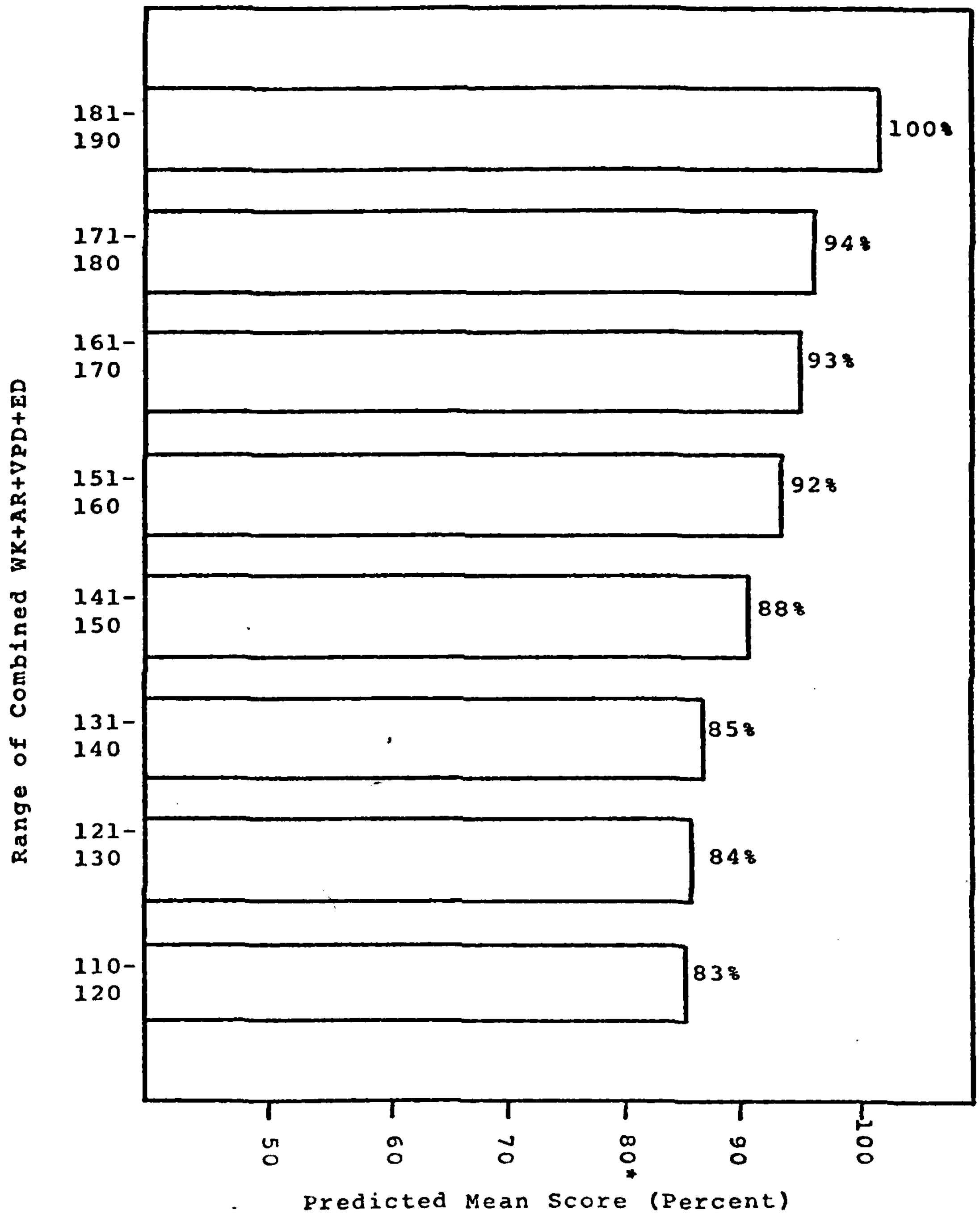

Figure 5. Expectancy Chart Showing Percent Predicted Performance Score (FL2) Based on Best Four-Variable Model

*80% passing score.

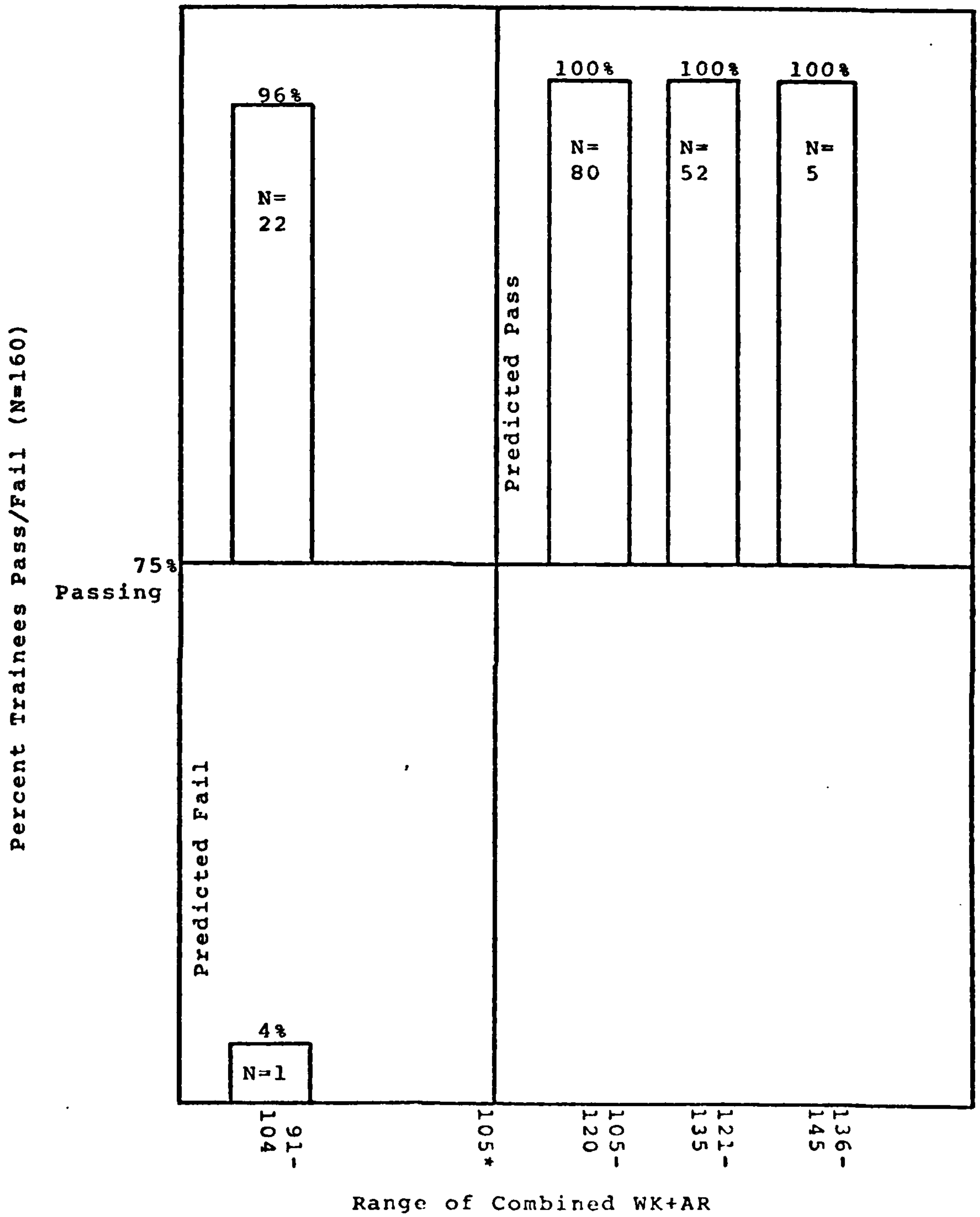

Figure 6. Expectancy Chart Showing Relationship Between ASVAB (WK+AR) Scores and Final School Grade

*Minimum ASVAB for course entry.

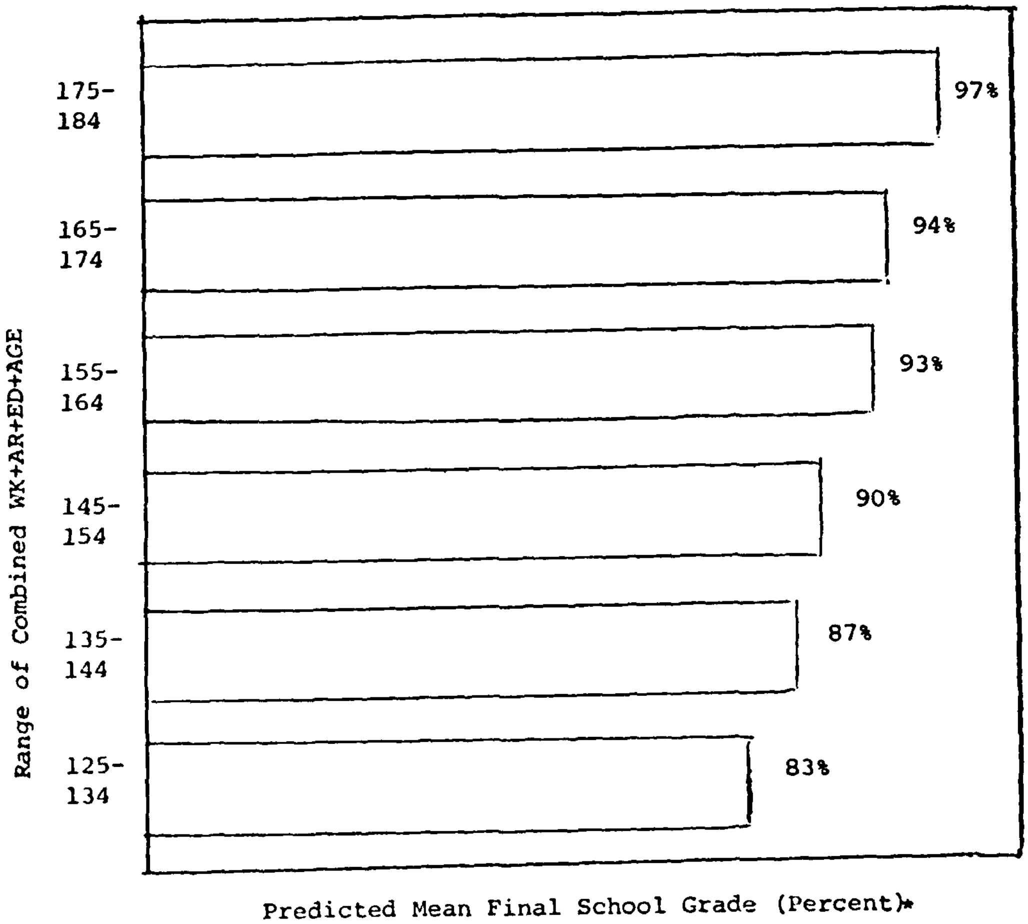

Figure 7. Expectancy Chart Showing Predicted Final School Grade Based on Best Four-Variable Model

*75% Passing score.

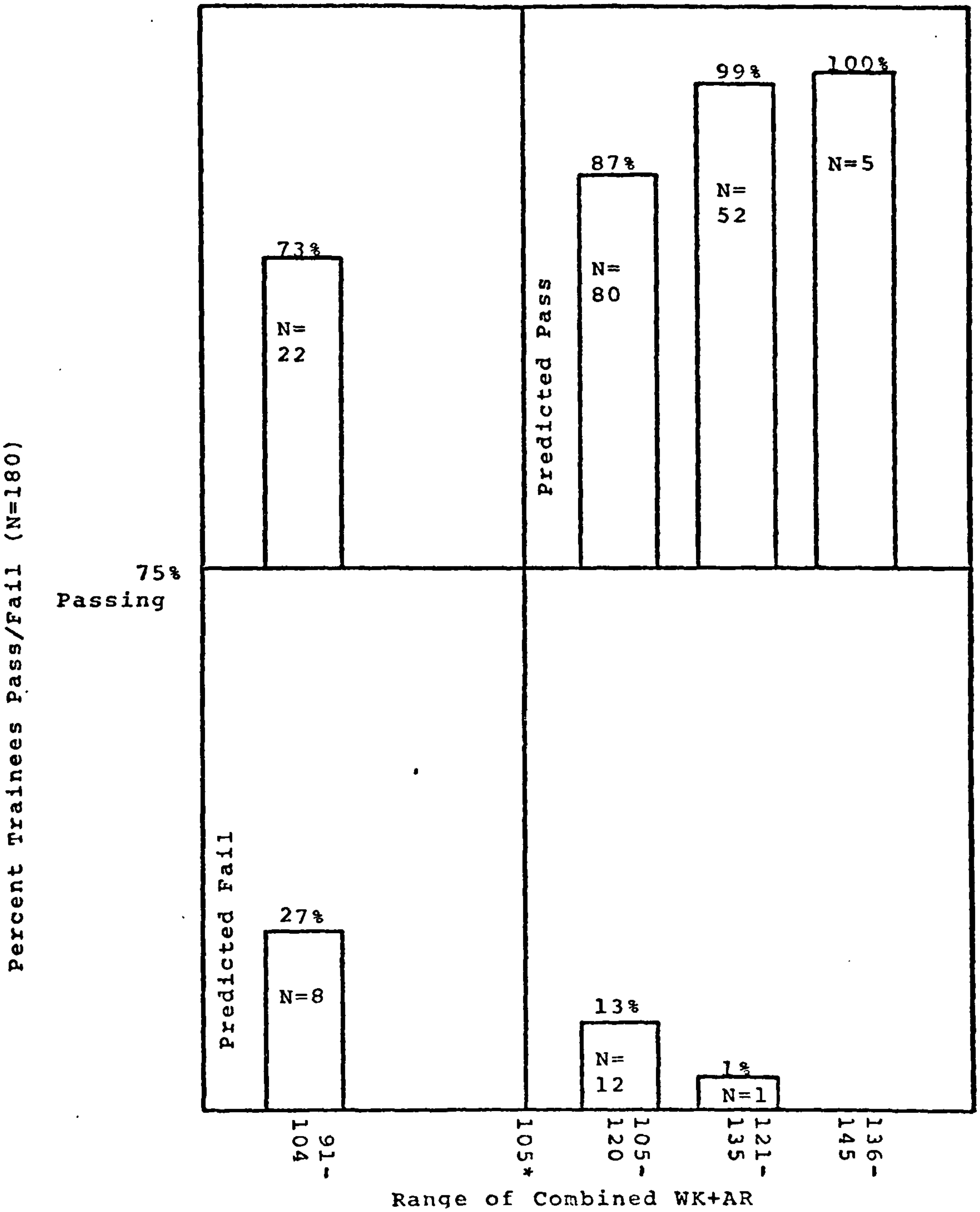

Figure 8. Expectancy Chart Showing the Relationship Between ASVAB (WK+AR) Scores and Failure to Complete the Course.

*Minimum ASVAB for course entry.

SECTION IV

DISCUSSION

The following discussion is in three parts. First, the validation of the ASVAB subtests currently used in the selection of signalman trainees and the individual characteristics which appear to be related to receiving Morse code visually are discussed. This is followed by a discussion of the attrition data gathered during the study. Finally, a model is proposed for use in the signalman course which could be expected to facilitate the learning and practice of communication via Morse code.

VALIDATION

A concurrent validation of the ASVAB WK and AR subtests as predictors of signalman success was accomplished. The ASVAB subtests WK and AR correlated with FSG .544 and .535, respectively, and .67 in combination. While a correlation of this magnitude is respectable, it may have been greater in a random sample of the total Navy population. The best predictors of course success were the ASVAB subtests WK and AR followed by VPD and VRT. The results indicated that the WK and AR subtests currently used for assigning trainees to the signalman course are good predictors of both performance and FSG. Visual Pattern Discrimination and VRT were not as strong as anticipated for predictive purposes for the total group. Evidently, the signalman task is most heavily influenced by cognitive factors.

While VPD and VRT did not contribute enough to the variance to be generally practical as predictors for course selection, the addition of VPD to the model would provide a finer discrimination if and when selection ratios eventually permit the use of a more discriminating selection instrument.

Some conclusions can be made regarding the nature of the signalman Morse code task. The VPD, for the most part, samples the ability to perceive the light signal and identify the length of exposure (dot-dash); i.e., a spatial factor. The VPD entered the four-variable model for FL1, and FL1 scores were correlated significantly with FSG. While VPD did not account for a large enough share of the variance for the total sample to be practical as a predictor of course success, apparently it can provide an early indication of those who will experience some difficulty in the performance phase. It could be used at the school level to identify potential failures and identify those individuals requiring special assistance.

Visual Pattern Discrimination turned out to be the best predictor for performance and FSG for the bottom aptitude quarter of the sample. The selection and training of individuals at the low end of the aptitude continuum is of major concern for the military. As the population of 18 year olds decreases, the requirement to utilize more marginal, low-aptitude personnel increases. Past experience has shown that a number of these individuals will be successful but, to date, no selection instruments have successfully predicted which ones. The VPD test appears to be sufficiently sensitive for determining which low-average aptitude individuals can succeed at the signalman visual reception task. Used as a pretest, VPD could identify individuals requiring additional assistance, and it may even be useful as a training tool early in the course to acquaint the trainee with follow-on training.

Visual Reaction Time entered the four-variable model for FL3 as a significant contribution. Apparently, as trainees reach maximum performance level; i.e., are knowledgeable in the code, the ability to react quickly is a factor in the speed of receiving code. Visual Reaction Time, then, is a predictor of speed and accuracy in visual reception of Morse code. Again, for practical purposes, VRT does not contribute sufficiently to the variance to warrant use in the selection battery as a predictor of course success. The simple VRT test as conducted in this study was probably not difficult enough to get at the complexity of the total information processing task. A choice VRT test probably would have better served the purpose of prediction. However, the experimenter was looking for a relatively simple procedure for the school staff to use as an indication of possible difficulties which might be encountered by the trainee later in the course.

An unexpected result was the relationship of Age to FSG. The age range was 17 to 30 years, and the older trainees received better grades. These were career individuals who had returned to school for cross-training in another occupation; they may have been better motivated than younger, newly enlisted individuals.

Years of formal schooling was positively correlated with FSG. Whatever factor determines an individual's ability to remain in a formal educational setting significantly affects his ability to profit from training. This could be simply "stick-to-itivity" in some cases and aptitude in others. Higher aptitude individuals tend to find formal schooling rewarding and are apt to profit from the same and continue longer, while many with lesser ability stay in the school setting despite the fact that their grades are less than adequate. For the total sample, it is interesting that while VPD and VRT entered into the predictor models for the three performance tests, neither achieved the .10 significance level required to enter the model for FSG. Apparently, the final grade is more heavily weighted toward the cognitive, academic factors than is the flashing light performance grade. Visual Pattern Discrimination, however, turned out to be a better predictor of FSG for the bottom one-fourth aptitude group than the ASVAB scores, justifying somewhat the concern expressed by instructors that the ASVAB does not accurately predict performance for all trainees.

The major reason for trainee difficulties is likely a failure to place enough emphasis on the performance training phases for the lower aptitude individuals. In this study, trainees had mastered the Morse code prior to the performance phase. Nevertheless, there were significant differences in scores obtained by High and Average trainees on the visual code receiving task. There are several possible explanations for this. Practice strengthens the memory trace for information stored in memory. Perhaps the lower aptitude individual requires more rehearsal to strengthen the memory trace; i.e., practice time may have been insufficient for permanent storage of the information in memory. Another possible explanation is that lower aptitude individuals require more time to retrieve the information from memory at time of decoding. Five words per minute may have been too fast at this stage in their learning. At any rate, from the data obtained, information processing for signalmen appears to be more related to cognitive than to perceptual factors (once minimal perceptual requirements; e.g., light intensity, are met).

The data analysis indicated that the addition of the VPD and VRT variables to the currently used two-variable ASVAB model would be useful for predictive purposes. While the difference between the multiple correlations for the two- and four-variable models for FL1 was not statistically significant, the differences between the two- and four-variable models for FL2 and 3 were significant as was the difference between the two- and four-variable models for FSG.

Due to the restricted sample employed in this study, traditional methods (Taylor and Russell (1939), Naylor and Shine (1965) in Zedeck (1974), p. 127) were precluded from use in estimating predictive efficiency. Hence, expectancy tables were based on raw data. For two performance grades and FSG, the multiple correlations obtained for the four-variable models were significantly different ($p = < .01$) from those obtained for the two-variable WK + AR models. If, in the future, it should be decided that a finer discrimination is desirable for selection purposes, the VPD test may be worth adding to the selection battery. The ASVAB is a good predictor of success in the signalman course; however, the 105 cutoff score may be too high since the majority of those trainees predicted to fail did indeed pass the course. That is, it may be possible to reduce the quality of input to the course through (1) the use of the VPD test for identifying problem trainees and (2) longer practice periods for lesser qualified individuals.

INDIVIDUAL CHARACTERISTICS RELATED TO RECEIVING MORSE CODE VIA FLASHING LIGHT

The ASVAB subtest scores were correlated with flashing light performance. Significant positive correlations of .30, .24, and .28 were obtained between WK and FL1, 2, and 3. Significant positive correlations of .31, .30, and .31 were obtained between AR and FL1, 2, and 3. This indicated that the cognitive knowledge and reasoning ability measured by these subtests were important factors in learning and performing the signalman task. Visual Pattern Discrimination correlated significantly, .24 and .27, with FL1 and 2 indicating that the spatial factor measured by this test was a significant factor in receiving code visually. Significant correlations were obtained for VRT with FL2 and 3 of -.16 and -.21. The significant negative correlations for VRT with performance indicated that there was a significant relationship between an individual's reaction time and his ability to receive flashing light messages; that is, the quicker the reaction time, the better the receiving score.

It was expected that WK and AR would be significantly correlated with learning the code and that the VPD and VRT measures would be significantly correlated with performance. As expected, for the total group, WK and AR were significantly correlated with learning the code. They were also good predictors of ability to receive flashing light messages, having accounted for the major proportion of the variance. Visual Pattern Discrimination ability and VRT were also correlated with receiving flashing light messages. Word Knowledge and AR proved to be the best predictors of FL1, followed by VPD and Age. This indicated that the cognitive factors measured by WK and AR outweigh the spatial and reaction time factors inherent in receiving flashing light messages. However, the VPD and VRT do measure some abilities required for the task which are not common to the WK and AR subtests. For FL2, WK and AR proved to be the best predictors followed by VPD and Education. For FL3,

MC and AR proved to be the best predictors followed by VRT and WK. The correlation of MC with FL3 scores may be due, in part, to the fact that sending messages by semaphore flag was included in the sixth week test score; however, the correlation of VRT with FL3 may mean that reception speed, and hence reaction time, becomes more important in the later weeks of training when factors other than code knowledge become important.

Significant correlations (.23 and .18) were obtained between VPD and WK and AR, respectively, indicating some overlapping or commonality of factors measured by these instruments. Correlations between VRT and WK and AR were not significant, indicating that VRT measures a factor or factors not measured by these subtests. Final "send" and "receive" (paper and pencil) test scores were correlated with performance scores reflecting that those who did well in the acquisition phase tended to do well in the performance phase of the course. Significant correlations were obtained between "send" (.18 and .21) and "receive" (.25 and .26) and FL1 and 2, respectively. These scores did not correlate significantly with FL3 probably because other components, including the ability to send messages via semaphore flags, are included in these test scores.

The correlations obtained indicate that VPD and VRT are indeed related to the ability to receive flashing light messages and measure factors other than those measured by the WK and AR subtests. The correlations obtained for the predictor variables WK, AR, VPD, and VRT with the criteria variables indicate that cognitive and reasoning ability and pattern discrimination and quick reaction time are all requirements for success in accomplishing the signalman information processing task. Furthermore, individuals who are successful in the public educational system stand a good chance of succeeding at the signalman task. Interestingly, VPD ability apparently compensates to some extent for cognitive ability, as reflected by the ASVAB subtests, since this test accounted for the major portion of the variance in performance and FSG for the one-fourth of the trainees having the lowest WK + AR aptitude scores.

ATTRITION

Of the total experimental population (180 trainees), 11 percent failed to complete the course. The majority of these were dropped from the course within the first 3 weeks.

There were no significant differences in ability between those who attrited and those who successfully completed the course. One could infer that reasons other than aptitude account for trainees' failure. It is probably safe to assume that these reasons are personal and motivational in nature.

TRAINING STRATEGIES

Although all graudates achieved graduation performance criteria the training program does not eliminate differences between High and Average aptitude trainees. However, lower aptitude individuals can be brought to mastery level for skills of similar difficulty to the one trained in this study by adapting training methods to aptitude level (Mew and Muller, 1972). One of the expected study outcomes was the matching of psychological variables to

particular learning strategies. Whether a student's own learning (cognitive) style is matched or mismatched to a teaching strategy can have a considerable effect on learning and performance (Pask, 1976).

The innovative cognitive strategies employed in learning the code were guided learning and practice and mnemonics. It can be inferred that the use of mnemonics facilitates the learning of Morse code, and that the addition of structure provided a unique contribution which further aided the learning process. Average aptitude individuals learned more quickly and achieved scores equal to High aptitude individuals using traditional study methods when these strategies were employed.

The results corroborate those of Mew and Muller (1972). In that study, Low aptitude auto mechanic trainees achieved scores equivalent to High aptitude trainees when learning was structured in procedural steps. Low aptitude trainees required slightly longer to reach criterion, however, not as long as they did using traditional training strategies. The assumption can be made from the results obtained in this study and that of Ainsworth (1979) that cognitive strategies can compensate for low capacity, although these individuals may still not be able to comprehend subject matter as complex as that comprehended by those of high capacity. Another assumption can be made in view of the study results that strategies appropriate for less bright individuals might not be appropriate for bright individuals who are probably better able to develop their own strategies. For example, too much structure may inhibit brighter trainees who have developed their own learning techniques. The introduction of strategies used in these studies to the signalman course would assist trainees in acquiring, retaining, and retrieving information. More effective training strategies may make it possible to utilize individuals who would not be admitted to the course as it is presently conducted. Figure 9 illustrates a model which is proposed to improve the training offered for signalmen. The model provides bridges; i.e., provides a way of organizing the learning situation. The instructional strategies evolve around the following essential elements:

- mnemonics
- structured learning and practice
- individually-paced instruction
- orienting tasks.

The learning package incorporating guided learning and practice and mnemonics was found to be most suited for acquisition of code for mixed groups and is a suitable cognitive strategy for the course. To aid in learning to receive code via flashing light, trainees would be introduced early in the course to the visual reception of code through the use of an "orienting task" (Visual Pattern Discrimination). The term "orienting task" is used to designate a method for inducing the trainee to perform particular kinds of operations; i.e., providing cues which may be in the form of questions, verbal commands, or visual stimuli.

TRAINEE

(To be measured at end of course)

Internal Processing Functions:

- Acquisition
- Retention
- Retrieval

STIMULI

(To be monitored periodically)

Trainee data acquisition

Trainee responses

TRAINEE DATA

Visual Pattern Discrimination pretest
Knowledge pretest
Aptitude
Prior training
Formal schooling
Age

TRAINING STRATEGIES

Acquisition

Orienting task

Guided practice

Structured learning

Pictorial aids (mnemonics)

Time--commensurate with ability level

Performance

Orienting task
(Visual Pattern recognition)

Practice time--commensurate with ability level

Figure 9. Major Subsystems in Training System for Optimizing Signalman Training

The end result of signalman instruction is the mastery of the ability to send and receive messages visually via Morse code. That Visual Pattern Discrimination is a difficult task which must be learned is indicated by the average score obtained (10.40, range 2-20 out of a possible 25 points) on the VPD pretest. The inclusion of this "orienting task" early in the course to alert trainees to the expected task should improve later performance.

Not all instructional strategies are designed to induce students to use cognitive strategies. They may instead be concerned with optimal allocation of trials or of time for learning the content and practicing the skill. The data obtained in this study indicate that while Average aptitude individuals attained scores equivalent to High aptitude individuals in the initial learning phase, they did not perform as well in visual code reception. While several factors could account for this, for all practical purposes, it can be assumed that "time to rehearse" was insufficient for these trainees. Lower aptitude individuals require more time to learn to criterion and more practice time to master code reception. Therefore, the instructional design should include sufficient time for these individuals to master the task. At the same time, High aptitude individuals could be accelerated. Because of individual differences in acquisition, retention, and retrieval skills and processing capacity, each trainee would start at a different place and progress at a different rate. Because of the interrelationships and interactions of the elements in the instructional sequence, and of individual differences among trainees, procedures for control over outcomes of instruction should be sensitive to these complexities.

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

This section contains the major conclusions derived from the study and proposes recommendations for improving the signalman course.

CONCLUSIONS

- Mnemonics and guided learning and practice were significant factors in facilitating the acquisition of Morse code.
- The innovative training strategies proved more effective for Average than for High aptitude trainees.
- The type of training materials used for code acquisition had no significant effect on performance (receiving code visually via flashing light).
- The signalman course, as conducted during this study, did not appear to minimize differences in performance across aptitude groups; i.e., while trainees met the minimum requirements for graduation, the training program did not maximize performance for the average aptitude trainee.
- Visual Pattern Discrimination ability is a significant factor in receiving Morse code via flashing light.
- The VPD test was better at predicting subsequent grades for low-Average aptitude individuals than for High aptitude individuals.
- The ASVAB, WK, and AR subtests were good predictors of code acquisition and performance for High aptitude individuals.
- Age and years of schooling were good predictors of final grade.
- The VPD appears to be a worthwhile addition to the selection battery when the decision is made to accept low-Average or marginal personnel into the course.
- The VPD, when used as an "orienting task" at the training level, should facilitate learning to receive code visually.
- Consideration should be given to lowering the cutoff score for entry into the signalman course. Of the trainees comprising the sample, 23 had combined WK + AR scores below the 105 cutoff for course entry. Visual discrimination ability apparently compensates to some extent for cognitive ability.
- The implementation of innovative learning strategies may provide a wider base for personnel selection.

- Attrition and setbacks appear to be more a motivational than an academic problem since there were no statistically significant differences in aptitudes between those who succeeded and those who failed.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that:

- the Visual Pattern Discrimination pretest be added to the selection battery for improved screening of Average and Low-aptitude individuals considered for the signalman course

- the instructional model delineated in section IV be adopted for training signalmen to include:

    - instructional materials containing guided learning and practice plus mnemonics

    - self-paced instruction to accelerate the learning of High aptitude trainees and permit lower aptitude trainees sufficient time to attain task mastery

    - the VPD test as an "orienting task" to facilitate code reception via flashing light.

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APPENDIX A

DESCRIPTION OF ARMED SERVICES VOCATIONAL APTITUDE BATTERY

DESCRIPTION OF
ARMED SERVICES VOCATIONAL APTITUDE BATTERY (ASVAB)

Test	ID	Items	Administration Time (Mins)	*Reliability Coefficients Form 6	Form 7
General information	GI	20	7	.60	.59
Numerical operations	NO	50	3	-	-
Attention to detail	AD	30	5	-	-
Word knowledge	WK	30	10	.89	.86
Arithmetic reasoning	AR	20	20	.80	.79
Space perception	SP	20	12	.75	.80
Mathematical knowledge	MK	20	20	.83	.82
Electronics information	EI	30	15	.81	.78
Mechanical comprehension	MC	20	15	.76	.74
General science	GS	20	10	.69	.75
Shop information	SI	20	8	.78	.76
Automotive information	AI	20	10	.81	.84
		300	2 hrs 15 min (aprx)	N=417	N=400

Armed Forces Qualification Test: There is no AFQT. However, an AFQT score (percentile) can be configured from the ASVAB utilizing the WK, AR, SP raw scores to place the individual in a mental group for statistical purposes.

*Kuder-Richardson Formula (untimed tests). Total sample size, form 6 = 417, form 7 = 400 (males)(preselected groups across three Navy Training Centers).

APPENDIX B

TYPES OF TRAINING MATERIALS

TABLE B-1. TYPES OF TRAINING MATERIALS

Training Material*	Type 1	Type 2	Type 3	Type 4
1. Hand-held code flasher (cardboard)	X			
2. Symbol cards (Opposites)	X			
3. Practice assignment	X			
4. Symbol sheet	X			
5. Guided learning and practice		X		X
6. Self-test		X		X
7. Chunking		X		X
8. Memory aids (mnemonics)			X	X

*Description of types of materials:

1. Hand-held code flasher: Slitted cardboard with movable white center which can be pushed up and down to expose white center representing flashing light. Speed differentiation can be manipulated to represent dots and dashes.

2. Symbol cards: Set of seven flash cards containing Morse code symbols. Each card indicating letter, the symbol and a letter and symbol which are opposite; .- for A and -. for N.

3. A sheet of paper assigning Morse code symbols to be identified and handed in to the instructor at the next class. No attempt is made to structure the learning process.

4. A sheet of paper containing the alphabet and Morse code equivalents.

5. Programmed text with learning guidelines and practice exercises.

6. Self-test: A criterion test with branching for repeated practice.

7. Chunking: Code is divided into sets--four sets of letters, one set each of numbers and punctuation marks. The sets are sequenced and become progressively more difficult.

8. Memory aids: Mnemonics (visual images) constructed to assist in learning to associate the alphanumerics with the symbol. These are associated with the phonetic alphabet.

APPENDIX C

INSTRUCTIONS TO STAFF AND TRAINEES

PATTERN DISCRIMINATION EXERCISE

INSTRUCTIONS

As signalmen you will be required to identify dots and dashes presented by a flashing light. This exercise is to see how well you can distinguish patterns of dots and dashes. Dots are of shorter duration than dashes. This is a D O T (flash several dots). This is a D A S H (flash several dashes).

You will be presented a number of sets of dots and dashes. You are to repeat the patterns on the scoring sheet I have just given you.

I will now present two practice sets. Look at the light and repeat on your answer sheet the pattern you see. (Use numbers one and two.)

Now look at the light and remember the sequence of dots and dashes. When I say "STOP," repeat the pattern on your answer sheet.

(Repeat directions for practice trial number two.)

"You should have as your first answer ..--. and -...- for your second answer. Now each time I say START, observe the dot-dash pattern closely. When I say STOP, repeat the pattern on your answer sheet.

APPENDIX D

ANALYSIS OF VARIANCE SOURCE TABLES

TABLE D-1. ANOVA SOURCE TABLE FOR "SENDING" DATA, ACQUISITION PHASE

Source of Variation	Sum of Squares	df	Mean Square	F	p
A: Aptitude	1438.67	1	1438.67	27.71	.0001
B: Treatment	2324.76	3	774.92	14.93	.0001
A x B	475.07	3	158.36	3.05	.03
S(AB): Error (a)	7891.95	152	51.92		
C: Trial	5877.65	2	2938.82	176.47	.0001
A x C	238.96	2	119.48	7.17	.001
B x C	780.21	6	130.04	7.81	.0001
A x B x C	70.67	6	11.78	.71	ns*
S(AB) x C: Error (b)	5062.50	304	16.65		
Total	24160.44	479			

*ns = nonsignificant

TABLE D-2. ANOVA SOURCE TABLE FOR "RECEIVING" DATA, ACQUISITION PHASE

Source of Variation	Sum of Squares	df	Mean Square	F	p
A: Aptitude	4392.30	1	4392.30	51.85	.0001
B: Treatment	1947.74	3	649.25	7.66	.0001
A x B	862.45	3	287.48	3.39	.02
S(AB): Error (a)	12876.77	152	87.72		
C: Trial	16397.00	2	8198.50	396.67	.0001
A x C	481.36	2	240.68	11.65	.0001
B x C	346.04	6	57.68	2.79	.02
A x B x C	165.79	6	27.63	1.34	ns*
S(AB) x C: Error (b)	6283.13	304	20.67		
Total	43752.58	479			

*ns = nonsignificant

TABLE D-3. ANOVA SOURCE TABLE FOR FLASHING LIGHT DATA, PERFORMANCE PHASE

Source of Variation	Sum of Squares	df	Mean Square	F	p
A: Aptitude	4914.11	1	4914.11	24.31	.0001
B: Treatment	1274.34	3	424.78	2.10	ns*(p=.10)
A x B	700.74	3	233.58	1.16	ns*
S(AB): Error (a)	30723.70	152	202.13		
C: Trial	2587.81	1	2587.81	52.35	.0001
A x C	10.51	1	10.51	.21	ns*
B x C	68.84	3	22.95	.46	ns*
A x B x C	124.14	3	41.38	.84	ns*
S(AB) x C: Error (b)	7513.70	152	49.43		
Total	47917.89	319			

*ns = nonsignificant

APPENDIX E

STRENGTH OF OBTAINED DIFFERENCES--STATISTICS

STRENGTH OF THE OBTAINED DIFFERENCES

The occurrence of a significant result says nothing at all about the strength of the association between treatment and scores obtained by trainees. A significant result leads to the inference that some association exists, but in no sense does this mean that an important degree of association necessarily exists. This can be misleading to the organization in determining the practical significance of the results.

To reinforce the meaning of the significant findings obtained in this study, an estimate of the strength of the statistical association was computed. The eta squared was computed to obtain a population index showing the relative or proportional reduction in the variance of Y (the dependent variable) given the X (independent variables) status or value of the observations. The index reflects the predictive power afforded by the relationship. In order to reduce the uncertainty; i.e., determine the extent to which knowing the independent variables (treatments) reduce the uncertainty about the dependent variables "sending," "receiving," acquisition, flashing light, and performance, eta squared (Peters and Van Voorhis, 1940), which is an unbiased estimate of omega squared (w^2) as discussed in Hays (1963, p. 325), was used to determine an estimate of the proportion of variance accounted for by treatments. The proportion of variance accounted for by treatment/"send" scores was .19, for treatment/"receive" scores, .18, and treatment/performance scores was .08. The derived correlation ratios obtained were .4388 (η^2 = .1926) for "send," .4290 (η^2 = .1841) for "receive" and .2851 (η^2 = .0813) for flashing light performance. The estimates imply that the statistical association is moderate between treatment and "send" and "receive" acquisition scores and minimal for performance.

Data were also analyzed to determine the statistical significance of the multiple correlations of the variables added to the currently used two-variable model. The difference between the multiple correlations for the two- and four-variable models for FL1 was not significant. The difference between the correlations for the two- and four-variable models for FL2 was significant (p = < .01). The difference between the correlations for the two- and four-variable models for FL3 was significant (p = < .05). The difference between the correlations for the two- and four-variable models for FSG was significant (F = 6.717, df = 2/131, p = < .01). These significant differences indicate that the addition of these variables to the selection battery would improve the selection procedure.

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